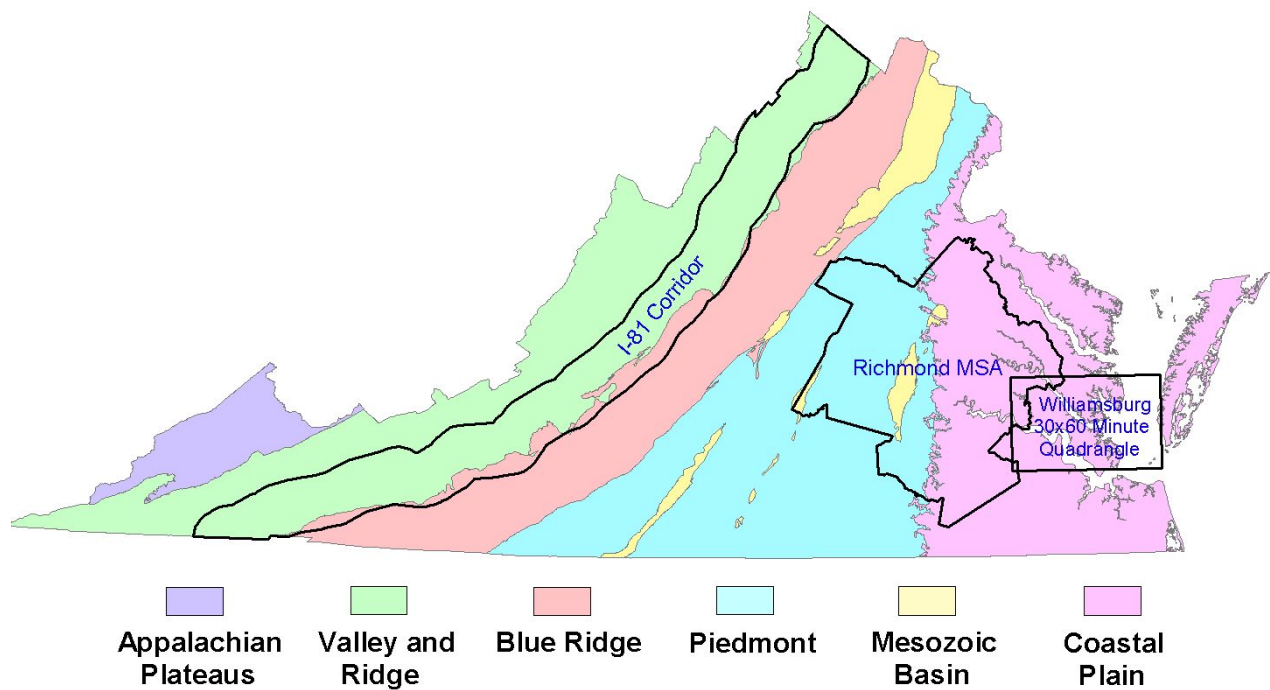


STATEMAP PROPOSAL - VIRGINIA

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No. 06HQPA0003*



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INDEX

LIST OF FIGURES	i
INTRODUCTION	
Long Range Plan	1
Virginia Growth	1
INTERSTATE 81 PROJECT	
Introduction	3
Location and Geologic Setting	3
Purpose and Justification	4
Strategy for Performing the Geologic Mapping	6
Preliminary Results and Prior Work	9
Deliverable Geologic Maps	10
RICHMOND MSA PROJECT	
Introduction	11
Location and Geologic Setting	11
Purpose and Justification	12
Strategy for Performing the Geologic Mapping	14
Preliminary Results and Prior Work	16
Deliverable Geologic Maps	17
WILLIAMSBURG 30 X 60 MINUTE QUADRANGLE PROJECT	
Introduction	18
Location and Geologic Setting	18
Purpose and Justification	19
Strategy for Performing the Geologic Mapping	20
Preliminary Results and Prior Work	20
Deliverable Geologic Maps	21
SUMMARY OF PREVIOUS STATEMAP ACTIVITY	22
REFERENCES	23

LIST OF FIGURES

Figure 1. Locations of proposed project areas	1
Figure 2. Projected population change, by county and municipality, in proposed project areas from 2000 to 2030.....	2
Figure 3. Best available geologic map coverage in Virginia	7
Figure 4. 7.5-minute quadrangles proposed for new geologic mapping within the I-81 Corridor project.....	8
Figure 5. 7.5-minute quadrangles proposed for digital geologic compilation within the I-81 Corridor project.....	9
Figure 6. 7.5-minute quadrangles proposed for new mapping and compilation within the Richmond MSA project area.....	16
Figure 7. 7.5-minute quadrangles proposed for new mapping within the Williamsburg 30- x 60-minute quadrangle project area.....	21

INTRODUCTION

The Virginia Department of Mines, Minerals and Energy, Division of Mineral Resources (DMR) seeks funding for geologic mapping along the Interstate 81 corridor, in the Richmond Metropolitan Statistical Area, and in the Williamsburg 30- x 60-minute quadrangle. These long-term projects focus our efforts on three regions of Virginia that are in great need of new and accessible geologic information. The maps we produce will enhance Virginia's ability to develop and conserve natural resources in a safe and environmentally sound manner to support a more productive economy.

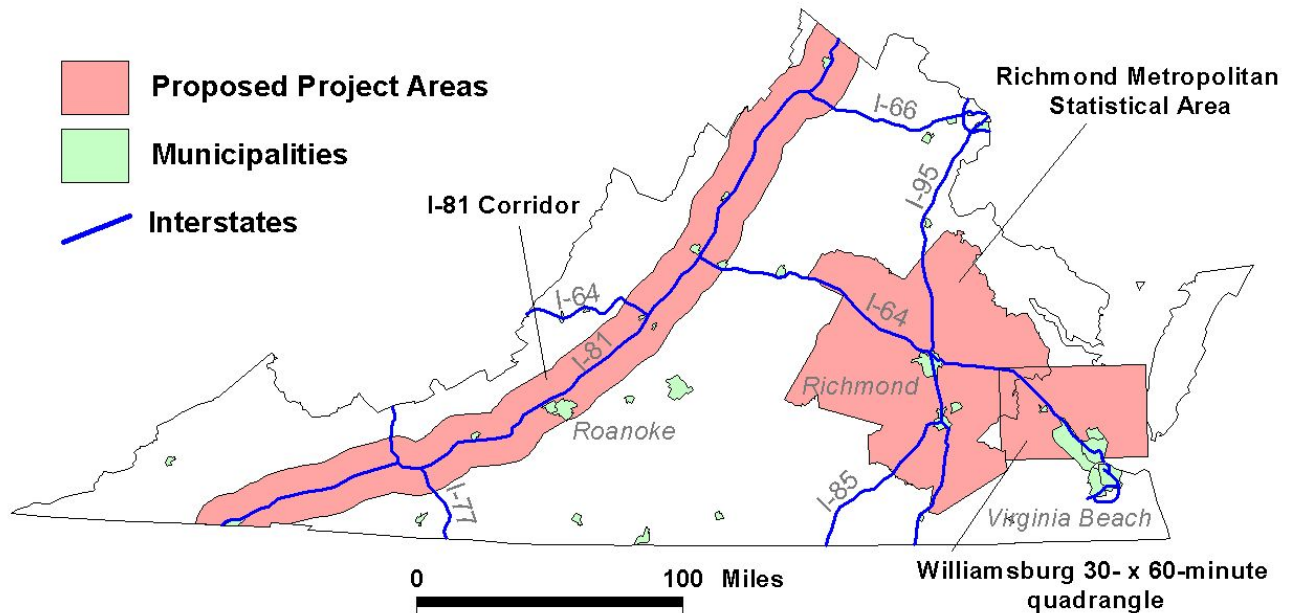


Figure 1. Locations of proposed project areas.

Long Range Plan

On October 3, 2003, DMR's Geologic Mapping Advisory Committee (GMAC) agreed that geologic mapping is needed in Virginia to locate water resources, develop economic products such as aggregate and sand, identify geologic hazards, protect natural resources, site waste disposal facilities, and develop roads and other infrastructure. The GMAC and DMR staff evaluated areas in Virginia with respect to these needs. At the end of this process, three areas where mapping would provide the greatest benefit were identified: western Virginia, particularly along the I-81 corridor; the Richmond metropolitan area; and along the I-64 corridor between Richmond and Virginia Beach. A long-term mapping strategy has been developed for each area. These strategies consider regional needs, development patterns, mineral resources, the location of existing mapping and staff resources.

Virginia Growth

Virginia is home to more than seven million people. The population of our state is expected to exceed nine million people by 2030 (Virginia Employment Commission, 2003).

Two thirds of this growth is expected in the Washington D.C., Richmond, and Virginia Beach–Norfolk–Newport News areas (Figure 2). Much of the remaining growth will occur near major highways such as Interstate 81.

Approximately one million people currently live within 10 miles (16.1 km) of I-81 (U.S. Census Data, 2000). Municipal centers in the I-81 corridor include the cities of Winchester, Harrisonburg, Staunton, Lexington, Roanoke, Salem, Wytheville and Bristol. The I-81 corridor's population is expected to grow more than 15 percent by 2030 (Virginia Employment Commission, 2003). Approximately 90 percent of this growth is expected to occur in areas that are currently unincorporated.

Approximately 1.1 million people live in 16 counties designated as the Richmond Metropolitan Statistical Area (U.S. Census Data, 2000). Municipal centers include Richmond, Petersburg, Hopewell, and Colonial Heights. The population of this area is expected to grow approximately 35 percent by 2030 (Virginia Employment Commission, 2003). Almost all of this growth is expected to occur outside of existing city boundaries.

Approximately 470,000 people live in the Williamsburg 30- x 60-minute quadrangle (U.S. Census Data, 2000). Municipal centers include Hampton, Newport News, Poquoson, and Williamsburg. The population of this area is expected to grow approximately 20 percent by 2030 (Virginia Employment Commission, 2003). Much of the growth will occur outside existing city boundaries.

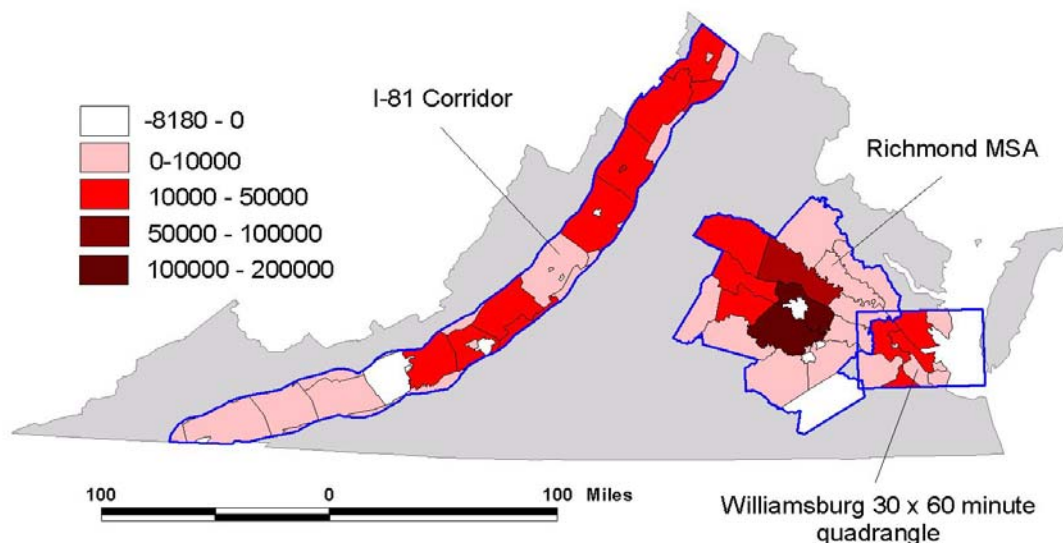


Figure 2. Projected population change, by county and municipality, in proposed project areas from 2000 to 2030 (Virginia Employment Commission, 2003).

INTERSTATE 81 CORRIDOR PROJECT

Introduction

DMR proposes to continue a concentrated multi-year effort to complete 1:24,000-scale geologic mapping and digital compilation of existing geologic maps along the entire I-81 corridor in Virginia. This portion of the Appalachian Valley is where most of the population lives, works, and travels on a daily basis. It is home to a variety of farms, industries, and commercial enterprises. I-81 is also a nationally significant transportation corridor that connects manufacturers and markets from the southern and northeastern United States.

For the purpose of this study, the I-81 corridor is defined to extend for 10 miles (16.1 km) on either side of the highway. DMR plans to complete 1:24,000-scale geologic mapping of all quadrangles that are wholly or substantially within this corridor. DMR also plans to selectively map quadrangles that are adjacent to the I-81 corridor in areas of current or future growth and in areas where detailed geologic mapping is warranted because of structural or stratigraphic complexity.

Intermediate products for this study will be 1:24,000-scale geologic maps of single or multiple quadrangles, to be published in paper or digital form, and a series of open-file reports on CD that contain files for the current extent of the geologic compilation. The final product will be a 1:24,000-scale digital compilation of the entire corridor.

Location and Geological Setting

I-81 extends for 325 miles in western Virginia, along the Appalachian Valley. It is the longest interstate in Virginia and has 90 interchanges, including intersections with Interstates I-66, I-64, and I-77. Two proposed Interstates, I-73 and I-74, will also intersect with I-81. Since its completion in the 1960's, I-81 has become the "main street" of western Virginia, serving as a corridor for travel, commerce, and development.

Industries and commercial businesses have located along the I-81 corridor to take advantage of the transportation system. Abundant high quality groundwater supplies in some areas have also attracted industries. Away from municipal centers, agriculture is the dominant industry. In 2002, the 12 counties that I-81 passes through contained approximately 11,850 farms on approximately 1.75 million acres (U.S. Department of Agriculture, 2002). This includes nearly 10,000 livestock operations.

The Appalachian Valley contains headwater portions of five major watersheds. Three of these watersheds are located on the eastern side of the eastern continental divide. The Shenandoah-Potomac and James rivers begin in the north and north-central parts of the Valley. Water from these rivers eventually flows into the Chesapeake Bay. The Roanoke River begins in the central Valley and flows into North Carolina where it enters Albemarle Sound and eventually the Atlantic Ocean. The New and Tennessee rivers, in the southern part of the valley, flow northwest and southwest, respectively, and ultimately enter the Mississippi river system.

The I-81 corridor is predominately underlain by clastic and carbonate sedimentary rocks of the Valley and Ridge geologic province. Metamorphic and igneous rocks of the Blue Ridge geologic province underlie a portion of the eastern edge of the corridor.

Early to late Paleozoic-age limestone, dolostone, sandstone, and shale comprise much of the Valley and Ridge province. These rocks formed from sediments that were deposited in a variety of terrestrial and marine settings. Folding and faulting of these rocks, predominantly during the Alleghanian orogeny, has produced complex geologic structures. Subsequent erosion has resulted in a distinctive topography that is dominated by alternating linear ridges and valleys. The stratigraphic sequence in the Valley and Ridge geologic province was first mapped at a scale of 1:250,000 by Butts (1933 and 1940). Butt's nomenclature remains largely intact. Subsequent quadrangle, county and 30- x 60-minute quadrangle mapping in portions of the project area have identified additional evidence for faulting and folding and refined the stratigraphy. It is anticipated that the proposed project will continue to identify map-scale structures, harmonize the portrayal of regional tectonic features, and establish a consistent nomenclature in this portion of western Virginia.

Rocks of the Blue Ridge geologic province are Middle to Late Proterozoic and early Paleozoic in age. The older rocks exist as basement and are unconformably overlain by the younger rocks. Both groups of rocks may overlie a major decollement and sit atop rocks that are thought to be correlative to those exposed in the Appalachian Valley. Contacts between Blue Ridge rocks are commonly sheared, making original relationships difficult to determine.

Purpose and Justification

Water resource location, economic product development, geologic hazard identification, natural resource protection and infrastructure development are important issues along the I-81 corridor. Some of these issues are at a critical stage. The need to locate aggregate and identify geologic hazards is very important as Virginia embarks on a two-decade project to expand I-81 and to possibly develop an adjacent long-haul rail system. The need to locate additional water resources, made even more evident during the recent drought, continues as development expands. The need to protect natural resources including river systems, forests, groundwater supplies, mineral resources, cave systems, and open space is also increasing in response to development pressures. This project will provide useful information at an appropriate scale to address the issues identified by the GMAC in the following ways:

Water Resource Location

Cities and towns in western Virginia obtain their water supplies from groundwater aquifers, surface reservoirs, or a combination of the two. Away from municipal centers, drilled wells are the primary water sources for residents, businesses, and industry. Well yields vary depending upon rock type, location, and depth. In karst and fractured rock aquifers, well yields are unpredictable. Supplies are typically adequate for residential use, but higher yield supplies for industries and municipalities are more difficult to locate. Some surficial deposits in the Appalachian Valley are significant reservoirs for groundwater. Groundwater residing in alluvial fan deposits supplies many businesses in the Valley, including those that require a high quality water source such as Coors Brewery, Merck

Chemical, Hershey's Chocolate, and McKee Foods. Detailed geologic mapping will provide useful information to municipalities, businesses, and industries when siting future wells.

Economic Product Development

The potential for additional aggregate resources exists along the I-81 corridor. The identification of these resources for quarrying will support continued economic development in the region and provide building material for the expansion of I-81 and new structures. High calcium limestones also exist in the corridor. The demand for these rocks is increasing as clean air regulations come into effect. A wide array of mineral resources have been mined in the past along the I-81 corridor, including crushed and dimension stone, metals, clay, and sand. Detailed geologic mapping will provide useful information to mining companies to further develop the region's mineral resources.

Geologic Hazard Identification

Sinkholes are significant hazards along large parts of the I-81 corridor. Between 1971 and 2001, almost 350 sinkholes were discovered in the I-81 right-of-way (Dorman, 2001). In 2001, three successive sinkhole collapses occurred in the median of I-81 within less than a month. Sinkholes are present in other portions of the corridor as well (Hubbard, 1983; Hubbard 1988; Hubbard, 2001). Many sinkhole collapses result from increased water infiltration related to changes in land use.

Landslides/block slides and slope stability are also hazards. These types of problems are common in the northern half of the corridor where the Blue Ridge Mountains meet the Appalachian Valley and in the southern half of the corridor where the hill slopes are steep. Landslides, limited debris flows, and extensive reworking of alluvial boulder deposits can occur during a period of heavy rainfall, like the one experienced with Hurricane Isabel in 2003 and Hurricane Ivan in 2004. Even on moderate slopes, some rock types and geologic structures create stability problems for structures and roads. Areas underlain by shale and some limestone formations are particularly susceptible to erosion, acidity, or foundation shift because of shrinking and swelling of residual clay soil.

Natural Resource Protection

Development pressures within the I-81 corridor are resulting in changes in land use. Open space is being converted to industrial, commercial, and residential use. These changes are certain to have both positive and negative effects on the region's natural resources. In many cases, the geology can play an important role in the nature and extent of these impacts. Detailed geologic maps will provide useful information to land use planners, natural resource caretakers, and environmental consultants who work in the corridor.

Water contamination is a significant problem in many parts of the I-81 corridor. Water quality in the region is impacted by a number of pollution sources, including agricultural run off, failing septic systems, and excessive sedimentation (Virginia Department of Environmental Quality, 2003). Many crops are fertilized with animal waste from concentrated feeding operations such as dairies and poultry farms. Nitrogen loads in the Shenandoah-Potomac basin increased 11 percent between 1985 and 2000, to an estimated total of 12,000,000 pounds (Virginia Department of Environmental Quality, 2003). Nutrients are a major water quality problem in the Chesapeake Bay, which is the ultimate receiver of water from the Shenandoah River (Environmental Protection Agency, 2002).

Approximately 52 percent of monitored streams and rivers in the Shenandoah-Potomac basin are threatened, not fully supporting, or not supporting their designated uses (Virginia Department of Environmental Quality, 2003).

Waste Disposal Facility Siting

As development in the region continues, additional solid and liquid waste disposal facilities will need to be constructed. These include municipal landfills, wastewater treatment plants, and land application sites. Detailed geologic maps will provide useful information to decision makers who site and regulate these facilities.

Roads and other Infrastructure Development

A statewide expansion of I-81 is in the planning stages and will occur over the next two decades. This expansion project will include the widening of the interstate, and possibly the installation of rail along the corridor and other improvements. Additional projects include the construction of I-73 and I-74 in the vicinity of Roanoke. Commercial, industrial, and residential development and associated utilities will likely follow road construction and expansion projects. Detailed geologic maps will provide useful information to the Virginia Department of Transportation, municipal and private utilities, and private and public land developers.

Strategy for Performing Geologic Mapping

Most 7.5-minute quadrangles in the I-81 corridor have geologic coverage that falls into one of three categories: published maps at 1:24,000 scale; unpublished or published maps at a scale between 1:24,000 and 1:250,000; and no maps at a scale of less than 1:250,000 (Figure 3). Our strategy is to compile existing blocks of published 1:24,000-scale maps and bring the level of mapping in other quadrangles up to 1:24,000-scale quality. Geologic and digital compilation will be continually expanded as new quadrangles are mapped.

Quadrangles to be mapped early in the project are those:

- where new geologic mapping is needed to address an important environmental, development or natural resource issue;
- adjacent to previously compiled geologic maps;
- where existing geologic mapping is nearly 1:24,000 quality;
- where existing geologic mapping has been completed at 1:100,000-scale.

This project will require mapping at least 70 quadrangles. Approximately one-half of these quadrangles have not been mapped at a scale of less than 1:250,000. The final product will involve digital compilation of these maps and approximately 60 additional quadrangles. It is anticipated that the I-81 corridor geologic mapping project could be completed in approximately 14 years with adequate staff and funding. For 2006-2007, the project will consist of the two separate sub-projects outlined below:

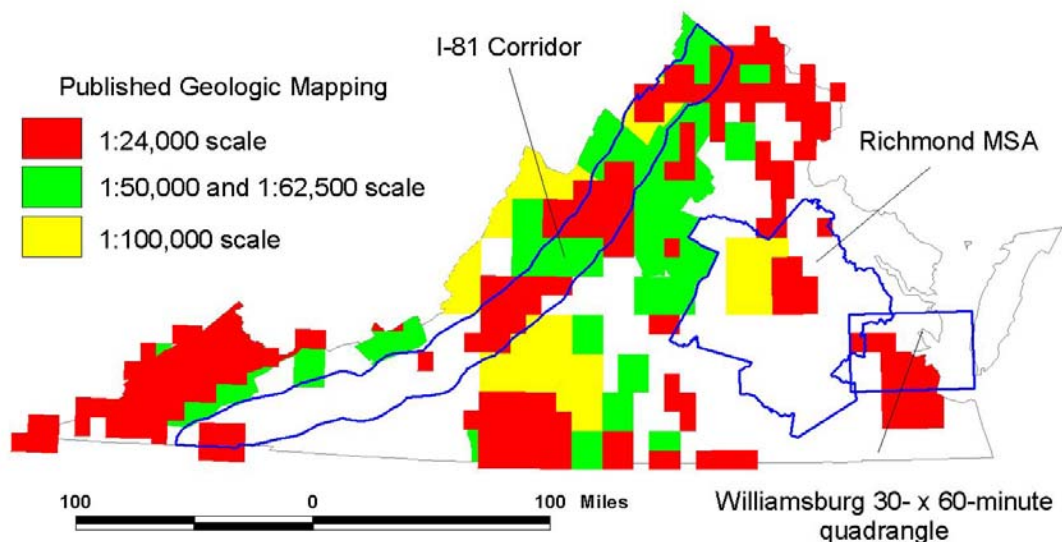


Figure 3. Best available geologic map coverage in Virginia.

1. Geologic Mapping

1:24,000-scale mapping of the Atkins ($\frac{1}{2}$), Elliston, Goshen, Montebello ($\frac{1}{2}$), Rileyville ($\frac{1}{2}$), and Saltville ($\frac{1}{2}$) quadrangles is proposed (Figure 4). All of the quadrangles, with the exception of Saltville, are entirely or substantially within the I-81 corridor. Approximately 40 percent of the Saltville quadrangle is within the I-81 corridor. The Saltville quadrangle has been chosen for completion because it contains significant historic and current mineral resources including salt and aggregate. In addition, voids created during salt mining are currently being used for natural gas storage.

As part of the mapping program, samples that are representative of significant map units will be collected. One portion of these samples will be submitted for whole rock analysis. A second portion will be used to make thin sections. A third portion will be placed into our rock repository. Whole rock analyses will include major, minor, trace and rare earth elements. The analytical results will be used to correlate rock types and identify potential mineral resources, including high calcium limestone. The results will be compiled into a database that is available to the public. One anticipated use is to identify the background concentrations of metals such as arsenic, barium, cadmium, chromium, lead, and mercury that are routinely detected in soil and groundwater during environmental investigations. Physical testing of potential aggregate resources may also be completed.

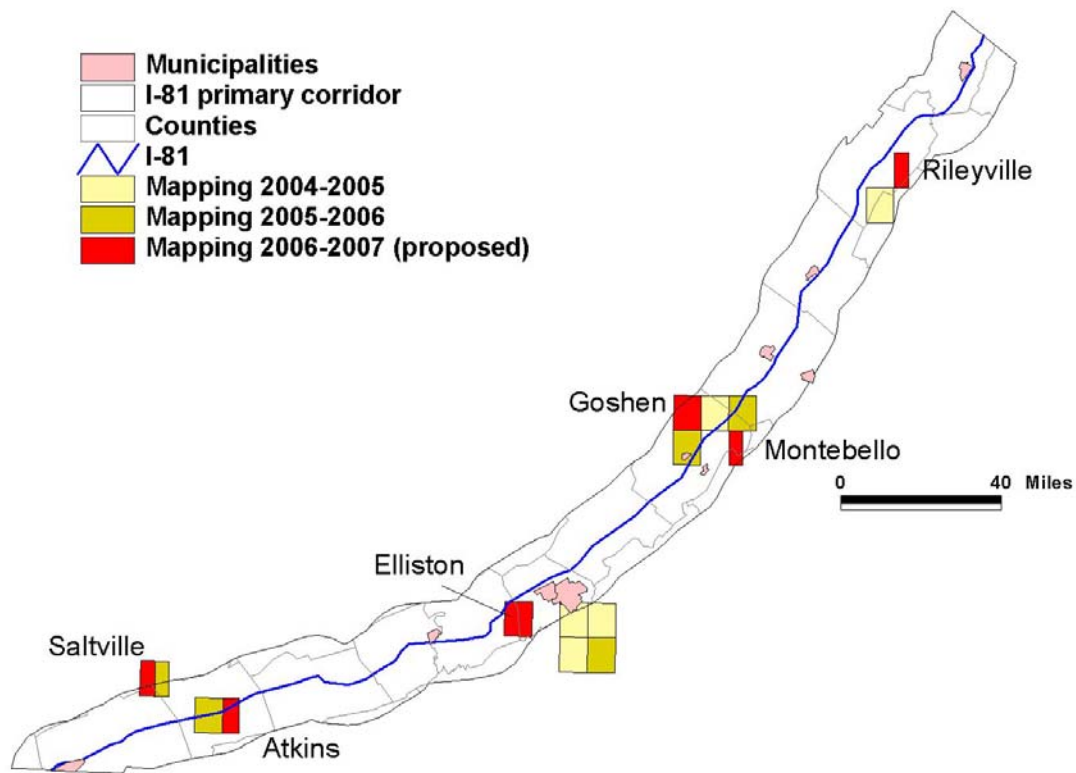


Figure 4. 7.5-minute quadrangles proposed for new geologic mapping within the I-81 Corridor project.

2. Geologic Compilation

This project will build upon our 2003 through 2005 STATEMAP geologic compilation, consisting of 18 1:24,000 quadrangles. This year we will add the following eleven quadrangles: Augusta Springs, Boones Mill, Brownsburg, Garden City, Hardy, Hamburg, Lexington, Marion, Radford North, Redwood and Staffordsville (Figure 5).

The Augusta Springs quadrangle was published 35 years ago, and will require significant field checking to examine new exposures, improve data density, and resolve map boundary “faults” and structural or stratigraphic inconsistencies. Mapping of the Radford North and Staffordsville quadrangles was completed more than 20 years ago (Schultz, 1983). Field review of these quadrangles is planned, as well as a review of nearby mapping completed since the quadrangles were mapped. It is anticipated that the original maps will require some editing. Geologic mapping of the other eight quadrangles has been completed during the past three years. As a result, significant field checking of these quadrangles will not be required.

The GIS files for ten of these quadrangles will be created by digitizing and editing the geologic features from the original maps as points, lines and polygons, attributing these features and incorporating any changes and new data resulting from field checking. Metadata and printable maps will be created based on the updated geologic information. The Marion quadrangle is being compiled in ArcGIS and should only require edits to the attribution and metadata.

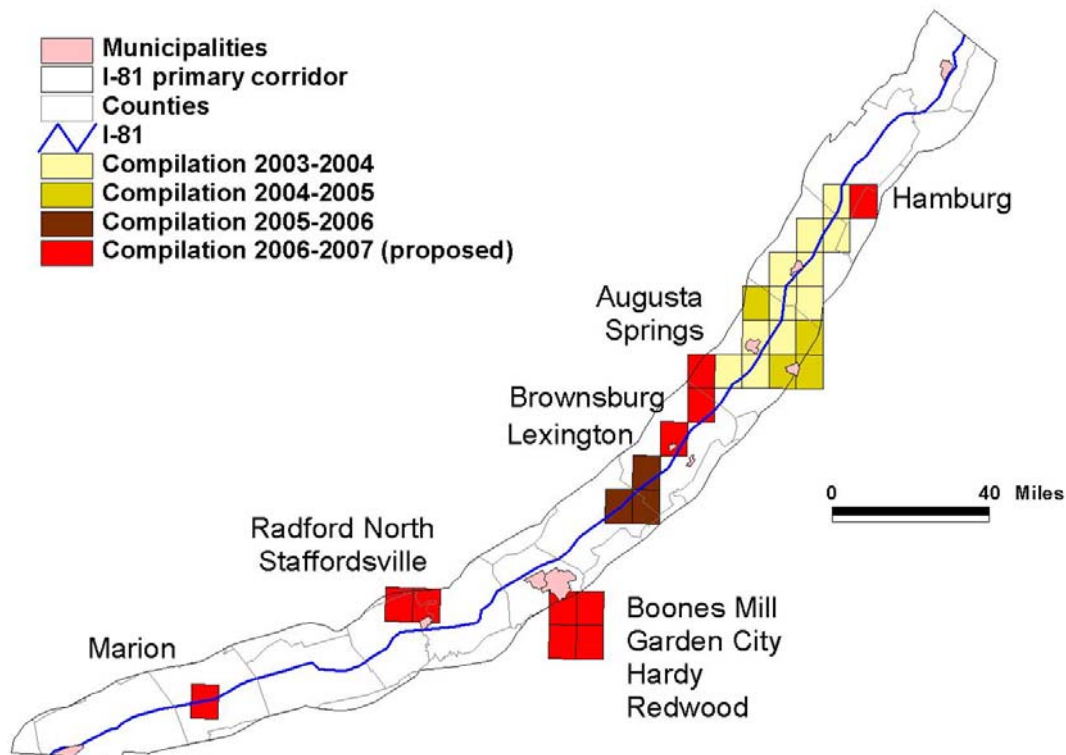


Figure 5. 7.5-minute quadrangles proposed for digital geologic compilation within the I-81 Corridor project.

Preliminary Results and Previous Work

New geologic maps of five quadrangles (Boones Mill, Brownsburg, Garden City, Hamburg, and Hardy) were completed under our 2004-2005 STATEMAP grant. Four of these quadrangles have been field reviewed. A field review for the Hamburg quadrangle is planned. The maps are also undergoing editorial review and will be released as open-file reports in the coming months. Our current STATEMAP project for the I-81 Corridor includes mapping the Lexington, Marion, Redwood, Saltville ($\frac{1}{2}$), and Vesuvius quadrangles.

Our 2003-2004 and 2004-2005 digital compilation projects included a total of fifteen 1:24,000 geologic maps along the Interstate 81 corridor between New Market and Greenville, Virginia (Figure 4). The completed compilation consists of attributed linework for

all features; bedrock geology as polygons; surficial geology as polygons; and attributed point data (bedding, cleavage, sinkholes, etc.) In addition, new and revised geologic cross-sections were created for each quadrangle. Both newly acquired and original field data have also been incorporated into the compilation. Approximately twelve months of fieldwork have been completed to resolve map boundary discrepancies, structural complexities, and to provide new data upon which to base cross sections. Our current STATEMAP digital compilation for the I-81 Corridor project includes the revision and compilation of the Arnold Valley, Buchanan and Natural Bridge quadrangles (Figure 5).

Previous Work

The Augusta Springs quadrangle has been published at 1:24,000 scale (Kozak, 1970). The Radford North and Staffordsville quadrangles have been mapped, but not published, at 1:24,000 scale (Schultz, 1983). The Boones Mill, Brownsburg, Garden City, Hardy, and Hamburg quadrangles were mapped at 1:24,000 scale during our 2004-2005 STATEMAP grant. These maps are in review and should be released as open-file reports within the next six months. The Lexington, Marion, and Redwood quadrangles are currently being mapped under our current grant. The Elliston quadrangle has previously been mapped at 1:100,000 scale (DMR, Unpublished data). Portions of the Rileyville quadrangle have been mapped at 1:62,500 and 1:100,000 scale (Allen, 1967; Rader and Gathright, 2001). The Montebello quadrangle has been mapped at 1:62,500-scale (Werner, 1966). A portion of the Montebello quadrangle in the Irish Creek tin district has been the focus of detailed mapping and investigation (e.g. Koschmann and others, 1942; Hudson, 1981). No published maps of the Saltville quadrangle exist, although a Masters Thesis (Ross, 1965) provides data for portions of the quadrangles.

Deliverable Maps

The deliverables for this project will be:

1. Geologic map and cross-section of ½ of the Atkins quadrangle;
2. Geologic map and cross-section of the Elliston quadrangle;
3. Geologic map and cross-section of the Goshen quadrangle;
4. Geologic map and cross-section of the ½ of the Montebello quadrangle;
5. Geologic map and cross-section of ½ of the Rileyville quadrangle;
6. Geologic map and cross-section of ½ of the Saltville quadrangle;
7. Digitally compiled geology as GIS files of the following eleven 1:24,000 quads: Augusta Springs, Boones Mill, Brownsburg, Garden City, Hardy, Hamburg, Lexington, Marion, Radford North, Redwood and Staffordsville (paper copies of each quadrangle that is part of the compilation will also be provided).

RICHMOND METROPOLITAN STATISTICAL AREA PROJECT

Introduction

DMR proposes to continue a multi-year effort to complete 1:24,000-scale geologic mapping and digital compilation of existing geologic maps in a portion of a 16-county area that has been designated by the U.S. Office of Management and Budget as the Richmond Metropolitan Statistical Area (MSA). According to the U.S. Census Bureau website, “the general concept of a metropolitan or micropolitan statistical area is that of a core area containing a substantial population nucleus, together with adjacent communities having a high degree of social and economic integration with that core.” DMR and the GMAC have targeted the Richmond MSA for investigation because it is a recognized jurisdiction that encompasses the area of future growth around Richmond.

This area in the Piedmont and Coastal Plain is situated at the intersection of three major interstates, I-95, I-64, and I-85 (Figure 1). It is home to approximately one in seven of Virginia’s citizens, and houses nearly every type of business and industry. Agriculture is a stable to growing part of the area’s economy, with approximately 4,300 farms on nearly one million acres (U.S. Department of Agriculture, 1997 and 2002). This area encompasses all or a portion of six regional planning districts.

DMR has ranked the 95 unpublished 7.5-minute quadrangles that are substantially within the Richmond MSA either a low or high priority. This ranking is based upon societal needs identified by the planning districts or other government agencies and the potential for mineral resources or geologic hazards by DMR staff. Quadrangles that are assigned a high priority ranking meet one or more of the following criteria:

- Significant change in land use anticipated;
- High potential for mineral resources;
- Known geologic hazards exist;
- Population center or highly developed area;
- Along an Interstate.

The goal of this project is to complete 1:24,000-scale geologic mapping of all quadrangles in the MSA that are identified as high priority. An ultimate goal is to use this data in combination with existing data on the low priority quadrangles to create a 1:100,000-scale geologic map of the entire MSA. Intermediate products for this study will be 1:24,000-scale geologic maps of single or multiple quadrangles, to be published in paper or digital form, and a series of open-file reports on CD that contain files for the current extent of the geologic compilation.

Location and Geological Setting

The Richmond MSA encompasses 16 counties in the Piedmont and Coastal Plain of Southeast Virginia. The cities of Richmond, Petersburg, Colonial Heights, and Hopewell are located along interstates I-95, I-64, and I-85. Several major U.S. Highways connect these cities with smaller communities both inside and outside of the MSA. The region

contains significant portions of three river basins. From north to south they are the York, James, and Chowan. The lower portions of the York and James rivers flow through the area and into the Chesapeake Bay. Several smaller rivers form the headwaters of the Chowan River, which begins in North Carolina and becomes part of the Albemarle / Pamlico-River Basin. The Chesapeake Bay and the lower reaches of the Albemarle / Pamlico-River Basin represent the largest and second largest estuarine systems in the United States, respectively.

The western half of the Richmond MSA is located in the Piedmont physiographic province. Crystalline rocks in the Piedmont portion of the MSA may be assigned to three separate terranes. From west to east they are the Chopawamsic terrane, the Goochland terrane, and the Southeastern Piedmont terrane. The Chopawamsic terrane contains metavolcanic, metaplutonic and metasedimentary rocks of similar age that are believed to have formed in an early to middle Paleozoic-age volcanic arc (Coler and others, 2000). The Goochland terrane is composed of multiply deformed igneous rocks and metamorphic rocks of uncertain affinity. At least a portion of the Goochland terrane is Mesoproterozoic in age. The Goochland terrane is separated from the Chopawamsic terrane by the Spotsylvania shear zone and from the Southeastern Piedmont terrane by the Hylas shear zone (Spears and others, 2004). The Southeastern Piedmont terrane contains a variety of metamorphic rocks, some of which appear to have volcanic protoliths. The late Paleozoic-age Petersburg Granite intrudes a substantial portion of the Southeastern Piedmont terrane in the project area. Another portion is unconformably overlain by Mesozoic-age sedimentary rocks of the Farmville, Richmond, and Taylorsville basins, which were deposited in a series of half-grabens. All three of these basins have had historic coal production and oil and gas exploration.

Much of the eastern half of the Richmond MSA lies within the Fall Zone. In this complex zone, Coastal Plain sediments overlie rocks of the eastern Piedmont. Both sediment and rocks are exposed and mappable. The age of sediments ranges from Cretaceous through Pleistocene. Estuarine and fluvial sediments of Miocene-Pliocene age are found capping the higher elevations and become thinner to the west, extending at least 20 miles west of the Fall Line (boundary at land surface between the Piedmont and Coastal Plain provinces) at Richmond.

Purpose and Justification

Water Resource Location

The City of Richmond and nearby counties of Henrico and Chesterfield in the Richmond MSA obtain their water supplies from surface sources, including the James River. Most other public and private water supplies in the MSA are groundwater-based. Well yields and water quality vary depending upon rock type, location, and depth. Shallow wells in the Coastal Plain may be vulnerable to surface contamination. In fractured crystalline rock aquifers, well yields are unpredictable, although supplies are typically adequate for residential use. Higher yield supplies for industries and municipalities are more difficult to locate. Detailed geologic mapping will provide useful information to municipalities, businesses, and industries when siting reservoirs and wells.

Economic Product Development

The Richmond Metropolitan Statistical Area (MSA) currently contains over 50 active mine and quarry operations, which produce economically significant quantities of crushed stone, clay, sand, gravel, and several industrial minerals. The crushed stone, clay, sand, and gravel resources provide local sources for high-demand construction materials. Industrial minerals such as aplite, vermiculite, and fuller's earth are exported from the Richmond area, providing business income and local jobs. Titanium and zircon are currently being produced from a nationally significant heavy mineral mine in the southern part of the MSA.

Past mineral production in the Richmond MSA includes many commodities not currently being produced, but which may have potential for redevelopment in the future. Coal was produced locally for over two hundred years; while it's not likely that coal mining will return to Richmond, deep coal deposits have been explored in recent years for coal bed methane. Gold, sulfide minerals, and mica were produced in the past and may still be present in significant quantities. Improvements in technology or changes in demand may make some of these commodities economically viable in the future. Detailed geologic maps will be critical for the evaluation and development of these resources.

Geologic Hazard Identification

Known geologic hazards in the Richmond MSA include acidic soils, shrink-swell soils, subsidence in the vicinity of abandoned underground mines, flooding, slope stability, and unsafe levels of radon and other potentially hazardous naturally occurring elements in soil and groundwater.

Surface collapses in the vicinity of historic coal mines in the Richmond basin have been a significant problem in recent years, because of residential and commercial development in former coal mining areas. Since most of these mines were abandoned in the 1800's, their exact locations and extents are often unknown. Acidic soils associated with the Eastover Formation are widespread in the eastern portion of the Richmond MSA. Water discharging from these soils can have a pH of 2 or 3. This can contribute to habitat degradation in streams and the premature failure of concrete and metal structures. The remnants of tropical depression Gaston in 2004 caused severe flooding and numerous landslides in downtown Richmond and vicinity. Understanding the geology of this area will help reconstruction and prevent future landslides.

Natural Resource Protection

Developmental pressures within the Richmond MSA are causing changes in land use. During development, open space is converted to industrial, commercial, and residential use. These changes are certain to have both positive and negative effects on the region's natural resources. In many cases, the geology can play an important role in the nature and extent of these impacts. Detailed geologic maps will provide useful information to land use planners, natural resource caretakers, and environmental consultants who work in the MSA. The Petersburg and Richmond National Battlefield sites are located in the Richmond MSA. The National Park Service has expressed interest in geologic mapping of these properties and surrounding areas to support park management.

Water contamination is a significant problem in many parts of Richmond MSA. Water quality in the region is impacted by a number of pollution sources, including

contaminated water run off and excessive sedimentation (Virginia Department of Environmental Quality, 2003). Non-point and point source pollution in developing areas also contributes fertilizers, pesticides, petroleum products, solvents, and other chemicals to streams and aquifers. Development often results in greater areas of impervious surfaces, resulting in increased surface overland flow into streams. 62% and 51 percent of monitored streams and rivers in the York and James River Basins, respectively, are threatened, not fully supporting, or not supporting aquatic life (Virginia Department of Environmental Quality, 2003). These rivers affect water quality in the Chesapeake Bay. Monitoring suggests that 93 percent of the Chesapeake Bay is threatened, not fully supporting, or not supporting aquatic life.

Waste Disposal Facility Siting

As development in the region continues, additional solid and liquid waste disposal facilities will need to be constructed. These include municipal landfills, wastewater treatment plants, and land application sites. Detailed geologic maps will provide useful information to the decision makers who site and regulate these facilities.

Roads and Infrastructure Development

Several major highway construction projects are underway or are being planned for the future, including the expansion and realignment of U.S. Highway 460. Detailed geologic maps will provide useful information to the Virginia Department of Transportation, municipal and private utilities, and private and public land developers.

Strategy for Performing Geologic Mapping

Most 7.5-minute quadrangles in the Richmond MSA have geologic coverage that falls into one of three categories: published maps at 1:24,000 scale; unpublished or published maps at a scale between 1:24,000 and 1:250,000; and no maps at a scale of less than 1:250,000 (Figure 3). Our strategy is to compile existing blocks of published 1:24,000-scale maps and bring the level of mapping in high priority quadrangles up to 1:24,000 quality. Geologic compilation will be continually expanded as new quadrangles are mapped.

Quadrangles to be mapped early in the project are those:

- where new geologic mapping is needed to address an important environmental, development or natural resource issue;
- adjacent to previously compiled geologic maps;
- where existing geologic mapping is nearly 1:24,000 quality.

This project will require mapping approximately 45 quadrangles (Figure 6). Unpublished data exist for many of these quadrangles, but only seven are covered by published mapping at a scale of greater than 1:250,000. The final product will involve the compilation of these maps and 13 previously published quadrangles. It is anticipated that the Richmond MSA geologic mapping project could be completed in approximately 14 years with adequate staff and funding. For 2006-2007, we propose the project outlined below:

1. Geologic Mapping

1:24,000-scale mapping of the Chesterfield and Drewry's Bluff quadrangles is proposed (Figure 6). Both quadrangles are located immediately south of the City of Richmond. These quadrangles are ranked by DMR as high priority because they contain highly developed and developing areas. The Drewry's Bluff quadrangle encompasses a portion of I-95.

As part of the mapping program, samples that are typical of significant map units will be collected. A portion of these samples will be submitted for whole rock analysis. A second portion of consolidated rocks will be used to make thin sections. A third portion of consolidated rocks will be placed into our rock repository. Whole rock analyses will include major, minor, trace, and rare earth elements. The analytical results will be used to correlate rock types and identify potential mineral resources. The results will be compiled into a database that is available to the public. One anticipated use is to identify the background concentrations of metals such as arsenic, barium, cadmium, chromium, lead, and mercury that are routinely detected in soil and groundwater during environmental investigations.

2. Geologic Compilation

This project will build upon our 2005-2006 STATEMAP geologic compilation, consisting of the Richmond, east-half of Bon Air, and west-half of Seven Pines 7.5-minute quadrangles. This year we propose geologic compilation and targeted remapping to complete the Bon Air and Seven Pines quadrangles (Figure 6). These quadrangles encompass highly developed and rapidly developing areas near the intersection of Interstates 95 and 64 and span the boundary between the Piedmont and Coastal Plain provinces. They are centrally located in the project area and will continue to provide a nucleus for the geologic compilation. Flooding potential, slope stability and radon are known or potential geologic hazards on both quadrangles.

The Bon Air and Seven Pines quadrangles were published in 1980 and 1974, respectively. Significant development has occurred in these areas during the intervening time, creating new exposures. This project will involve significant field checking to examine existing and new exposures. In areas where crystalline rocks are exposed, an emphasis will be placed on measuring the orientations of joints and filled fractures, which are lacking on the original maps. Targeted remapping of problem areas, the addition of structural data and the updating of stratigraphic nomenclature will also be performed. The GIS files for these quadrangles will be created by digitizing and editing points, lines and polygons from the original maps, attributing these features and incorporating changes and new data resulting from field checking. Printable maps showing the updated geology and metadata will be created.

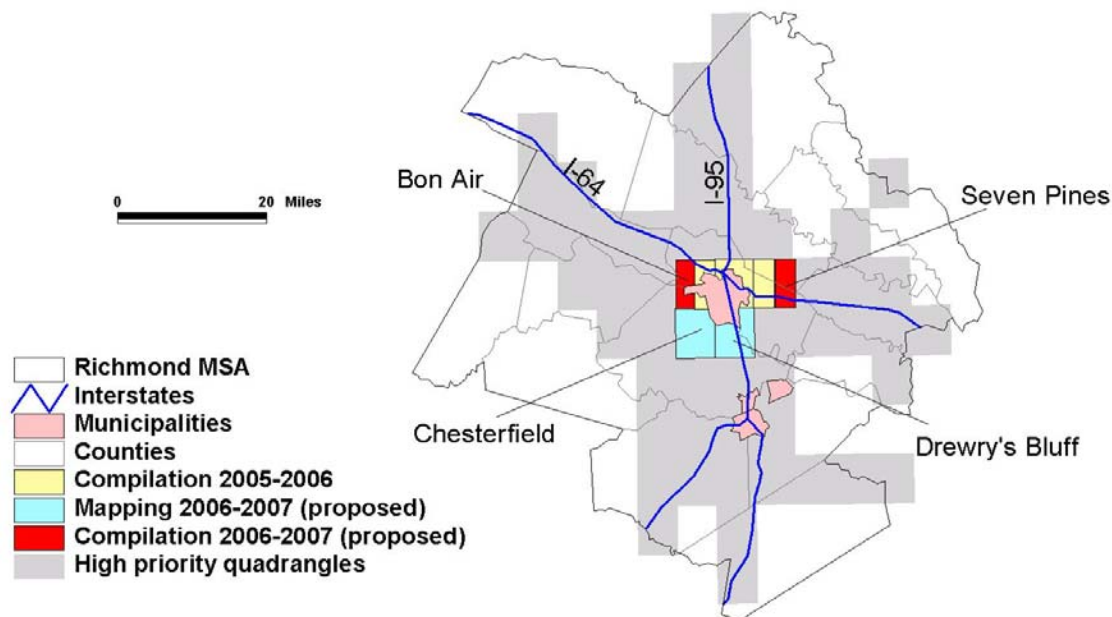


Figure 6. 7.5-minute quadrangles proposed for new mapping and compilation within the Richmond MSA project area.

Preliminary Results and Previous Work

DMR has met with staff of the Richmond and Crater Planning Districts to discuss the proposed project and to obtain information regarding critical issues that detailed geologic mapping may help address. Both districts provided feedback and priorities for investigation. The Richmond Planning District believes that mapping will be most useful in areas that will be experiencing development in coming years, especially west of Richmond. The Crater Planning district has indicated that its highest priorities are along the interstates and U.S. Highway 460, in developed areas containing large government and industrial facilities that may be redeveloped in the future, and in an area where elevated levels of uranium have been detected in groundwater.

Under our current STATEMAP project, a literature review and digitization of original published maps for the eastern half of the Bon Air, Richmond, and western half of the Seven Pines quadrangles is complete. Field checking of the existing maps is underway, with approximately 40 percent of the Bon Air quadrangle, 20 percent of the Seven Pines quadrangle and 15 percent of the Richmond quadrangle complete. Preliminary results from the field review include:

- 1) Identification of a variably indurated pebbly arkose layer, 0 to 20 feet thick, above the Petersburg Granite in the northeastern quarter of the Bon Air quadrangle. The arkose consists of medium-grained quartz and feldspar sand (the feldspar is variably weathered to clay at many locales), with well-rounded, matrix-supported, quartz pebbles scattered throughout the deposit, punctuated locally by discontinuous, clast-supported gravel layers (0.5- to 5 feet thick) consisting of pebbles and cobbles of mostly quartz, with few granitic clasts.

2) Collection of additional structural data within the Petersburg Granite and overlying Coastal Plain sediments, not compiled on the original published maps. Orientations of joints, aplite and pegmatite intrusions, compositional layering and foliation within the granite, and jointing/fracturing within indurated Coastal Plain units are being collected, analyzed and compiled into the new work.

3) Revision of Coastal Plain stratigraphic nomenclature. Evolution of Coastal Plain stratigraphy and correlation in the years since publication of the original maps necessitates a revamping of nomenclature in this area. Measured sections of new exposures in the Richmond area created by landslides following Tropical Depression Gaston in August 2004 have aided this process.

4) The Richmond quadrangle is being modified in the western part of the area; the unconformable contact between the Petersburg Granite and coastal plain sediments dips eastward. We have added and diminished areas underlain by the granite. The contact does not follow a consistent elevation. The eastern side of the quad has Coastal Plain units exposed. Clay (clayey silt unit) outcrops are exposed in streams that have been previously mapped as alluvium. In several locations the original map has the clay unit covered by alluvium on hillsides close to the James River. But in fact, the clay unit is exposed, possibly because of to recent mass movements. These outcrops are allowing us to modify and expand the contacts of the units. Upon closer observation of the clay unit, several joints sets can be seen. Measurements are being collected, analyzed and compiled.

Previous Work

The Richmond, Seven Pines, and Bon Air quadrangles have published 1:24,000-scale geologic maps (Daniels and Onuschak, 1974; Goodwin, B.K., 1980). A very small portion of the Drewry's Bluff quadrangle was mapped by Dischinger (1987). In addition, DMR has field data collected on all of the quadrangles in this project area that were collected for the completion of the 1:250,000-scale map of the Virginia's Coastal Plain (Mixon and others, 1989) or the 1:500,000-scale Geologic Map of Virginia (VDMR, 1993)

Deliverable Maps

The deliverables for this project will be:

1. Geologic map and cross-section of the Chesterfield quadrangle;
2. Geologic map and cross-section of the Drewry's Bluff quadrangle;
3. Digitally compiled geology as GIS files of the Bon Air and Seven Pines 1:24,000 quadrangles (Paper copies each quadrangle that is part of the compilation will also be provided).

WILLIAMSBURG 30 x 60-MINUTE QUADRANGLE PROJECT

Introduction

DMR proposes to continue its effort to complete geologic mapping and digital compilation in the Williamsburg 30- x 60-minute quadrangle (Figure 1). There are seven 7.5-minute quadrangles (and parts of two quadrangles on the Eastern Shore) that have not been mapped in detail (Figure 3). Six 7.5-minute quadrangles in the Williamsburg sheet were mapped between 2000 and 2002 with STATEMAP funding. Mapping the Ware Neck and Gloucester 7.5-minute quadrangles will complete Gloucester and Mathews counties. The outer rim fault of the Chesapeake Bay Impact Crater is projected through Ware Neck quadrangle. Interstate 64 lies within the Walkers quadrangle. The remaining four quadrangles lie mostly south of the James River. The Surry quadrangle includes Jamestown Island and vicinity where major infrastructure improvement is in process for the 400th anniversary of English colonization in America.

DMR relies heavily upon the use of its auger drilling rig for geologic mapping in the coastal plain. Although exposed map units may appear simplistic in some coastal areas, a refined delineation of the subsurface framework is critical to understanding the shallow aquifers and identification of sand/aggregate resources. STATEMAP funding will support assistance with mapping, drilling, sample analysis, and GIS compilation.

The final product for this project will be a 1:100,000-scale digital compilation of the entire Williamsburg sheet. We anticipate that it will take approximately two years to finish the project.

Location and Geological Setting

The Williamsburg 30- x 60-minute quadrangle lies completely within the tidewater region of Virginia (Figure 1). I-64 passes diagonally through the map area and is the major corridor for travel, commerce, and development between Richmond and the Virginia Beach–Norfolk–Newport News area. The trace of the interstate here defines the southern part of the “Golden Crescent” (an area of high population and development) that continues from Richmond to Washington DC. Other prominent geographic features are the York and James rivers, two major estuaries that are tributaries to the Chesapeake Bay. The eastern third of the Williamsburg sheet encompasses both shorelines of the lower Chesapeake Bay.

The region is home to major tourist attractions such as Colonial Williamsburg, Busch Gardens, Colonial National Historical Park, and Jamestown Settlement. It also contains industries such as Newport News Shipyard, coal and shipping terminals. Military bases include Fort Monroe, Fort Eustis, Yorktown Coast Guard Center, Langley Air Force Base, Yorktown Naval Weapons Station, and Camp Peary. This development is sometimes in conflict with the seafood industry centered in the lower bay and tributary estuaries.

The Williamsburg map area is entirely within the Coastal Plain province. Map units exposed above sea level consist predominately of estuarine, nearshore marine, and marine unconsolidated sediments of Pliocene and Pleistocene age. There is limited exposure of Miocene marine sediments in the project area. There is a substantial link between the morphology (scarps and flats) and Pleistocene stratigraphy because of world-wide sea-level changes during repeated glacial activity.

Below sea level, early Tertiary and Cretaceous sediments overlie basement rocks. Strata dip as a thickening wedge seaward. Depth to basement ranges from approximately 800 feet in the west part of the map area, 2,100 feet at Newport News to possibly 7,000 feet in the east at Cape Charles. However, the center of the Chesapeake Bay Impact Crater (33My) is located below Cape Charles, with a zone of fractured and faulted basement rocks extending more than 25,000 feet below sea level. The crater has affected basement and overlying Cretaceous through Eocene age sediments out to a diameter of 56 miles (Powars, 2000). The outer rim fault goes through the study area in the Gloucester, Mathews, Newport News, and Hampton quadrangles.

Purpose and Justification

Water Resource Location

Water supply in the project area comes from surface impoundments and wells. A desalinization plant is under construction for James City County. The city of Newport News has developed several reservoirs in the map area and is in the permit process for an additional reservoir in King William County. The impounded Chickahominy River and the Diascond Reservoir lie within the Walkers 7.5-minute quadrangle (proposed to be mapped in 2006-2007). Newport News and Gloucester have recently begun pumping and desalinizing brackish groundwater to increase their water supply.

Economic Product Development

Sand and gravel resources in the Williamsburg area are currently being lost to housing development. Most of the richest deposits in the coastal plain are found in the fluvial parts of the Pleistocene terraces, adjacent to major rivers (estuaries). Using DMR's auger drill rig greatly enhances the capability of locating potential aggregate resources. Fossil shell beds have been used as a source of lime (calcium carbonate) and may have a future use as a substrate for reseeding oyster beds.

Geologic Hazard Identification

Coastal flooding, elevated radon concentrations, minor earthquakes, and landslides, sinkholes, shrink-swell clays, and acidic soils are known or potential geologic hazards in the project area.

Natural Resource Protection

Development pressures within the project area are causing changes in land use. During development, open space is converted to industrial, commercial, and residential use. These changes are certain to have both positive and negative effects on the region's natural resources. In many cases, the geology can play an important role in the nature and extent of these impacts. Detailed geologic maps will provide useful information to land use planners, natural resource caretakers, and environmental consultants who work in the area.

Water contamination is a significant problem in some parts of the project area, which encompasses a lower portion of the Chesapeake Bay. Please refer to this section of the Richmond MSA project proposal for additional information about the York and James River Basins.

Roads and Infrastructure Development

Several major highway construction projects are underway or are being planned in the future, including the expansion and realignment of U.S. Highway 460. Detailed geologic maps will provide useful information to the Virginia Department of Transportation, municipal and private utilities, and private and public land developers.

Strategy for Performing Geologic Mapping

In order to compile at 1:100,000-scale, mapping will be done at 1:50,000-scale or better and 1:24,000-scale where necessary. At least 25 auger borings will be made in each quadrangle with subsurface information entered into a Microsoft Access database. Geologic contacts and point data will be compiled in a GIS.

For 2006-2007, we propose mapping the Walkers 7.5-minute quadrangle and the portions of the Surry and Claremont 7.5-minute quadrangles that are north of the James River. The Walkers quadrangle is within the area of overlap between the Richmond MSA and the Williamsburg 30- x 60-minute quadrangle (Figure 1). It contains a portion of Interstate 64 between Richmond and Williamsburg that is experiencing rapid residential and commercial development. The Jamestown Settlement is located on the Surry quadrangle. The National Park Service has expressed interest in geologic mapping of this area to support park management. This interest is timely given the substantial activities planned in celebration of the 400th anniversary of the settlement of Jamestown.

Preliminary Results and Previous Work

The mapping of Ware Neck quadrangle, being completed under our current STATEMAP grant, is about 50 percent complete. Over 50 power- and hand-auger borings have been made. Additional borings have been completed in the north-central part of the area where the Sedley, Yorktown, and Eastover formations may have been affected by faulting associated with the outer rim of the Chesapeake Bay Impact Crater. Tertiary sediments appear below sea level in a north-south line defined by Blackwater Creek and the North River. Work has just begun in the northeast part of Gloucester quadrangle.

Previous Work

All previously published maps and STATEMAP deliverables have been compiled at the original map scale (1:24,000 and 1:50,000) with a plotted map at 1:100,000 scale (Figure 6).

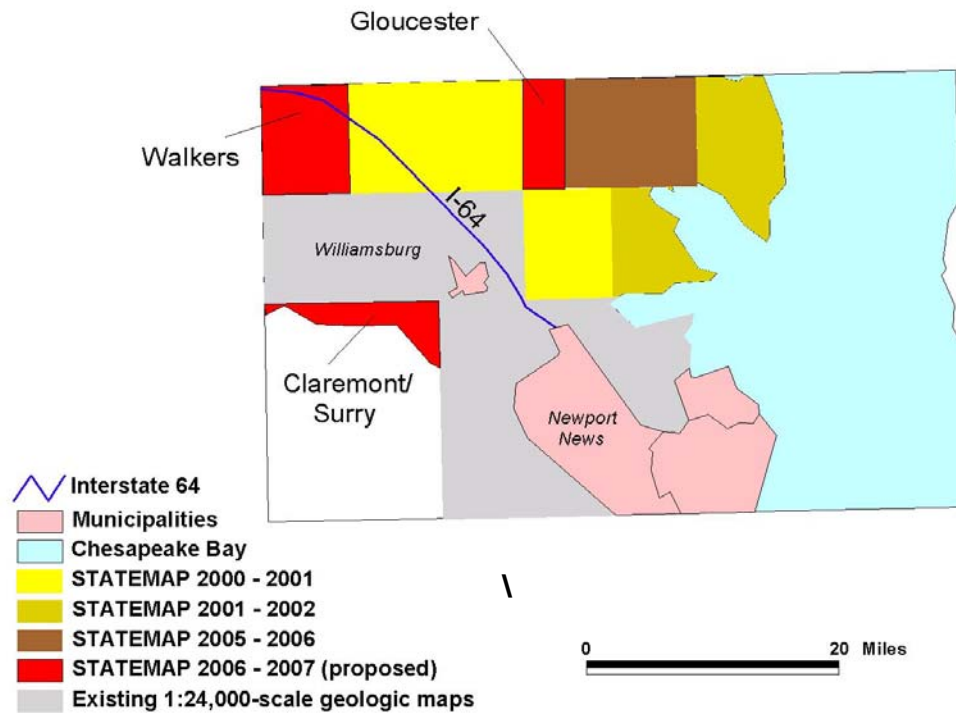


Figure 7. 7.5-minute quadrangles proposed for new mapping within the Williamsburg 30- x 60-minute quadrangle project area.

Deliverable Maps

The deliverables for this project will be:

1. Geologic map and cross-section of the Gloucester quadrangle;
2. Geologic map and cross-section of the Walkers quadrangle;
3. Geologic map and cross-section of the Surry and Claremont quadrangles, north of the James River;
4. Compiled geology of the Williamsburg 30- x 60-minute quadrangle as a work-in-progress.

SUMMARY OF PREVIOUS STATEMAP PRODUCTIVITY

DMR has a 100 percent on-time record for STATEMAP deliverables since the program began. Over the past few years we have had a growing and productive STATEMAP program.

Our 2005 STATEMAP project (\$227, 186 federal funding) consists of geologic mapping of all or a portion of seven quadrangles: Gloucester, Lexington, Marion, Redwood, Saltville, Vesuvius, and Ware Neck; a surficial geologic map of the northern half of the Grottoes quadrangle; and a geologic and digital compilation of all or portions of five quadrangles: Arnold Valley, Bon Air, Buchanan, Natural Bridge, Richmond and Seven Pines.

Our 2004 STATEMAP project (\$171,151 federal funding) consists of geologic mapping of the Boones Mill, Garden City, Hamburg, and Hardy quadrangles; a surficial geologic map of the northern half of the Grottoes quadrangle; and a geologic and digital compilation of four 1:24,000 quadrangles: Crimora, Parnassus, Waynesboro East, and Waynesboro West.

Our 2003 STATEMAP project (\$95,955 federal funding) consisted of a geologic and digital compilation of eleven 1:24,000 quadrangles: Bridgewater, Broadway, Fort Defiance, Greenville, Grottoes, Harrisonburg, Mt. Sidney, New Market, Staunton, Stuarts Draft, and Tenth Legion.

Our 2002 STATEMAP project (\$31,000 federal funding) consisted of mapping portions of five 1:24,000 quadrangles: Hayters Gap, Glade Spring, Chilhowie, Damascus, and the Virginia portion of Laurel Bloomery.

Our 2001 STATEMAP project (\$14,899, federal funding) consisted of mapping three 1:24,000 quadrangles in the Virginia coastal plain (Mathews, Achilles, and New Point Comfort).

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